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DECLARATION OF TRANSLATOR

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of any patent issued thereon.

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Filter element for filtering fluids

The invention relates to a filter element for filtering fluids with at least one filter unit which is arranged concentrically around its longitudinal axis, and which is supported in the direction of the respective throughflow of the fluid stream on at least one support element, at least some of the support elements being provided at least on their side facing the filter unit with channels for guiding the fluid, the channels extending with their longitudinal ribs which border them in spiral tracks along the support element, and the respective channel with its two free ends emerging on the opposing ends of the respective support element.

DE-A-198 37 257 discloses as a filter element a filter module which is simplified with respect to its structure and also enables production of a stage filter. Each layer of the filter medium as the filter unit consists of a bed of deep-bed filter material, these beds alternating with spacers, consisting of individual draining beds, which are stacked together with the filter beds without gaps horizontally on top of one another transversely to the longitudinal axis of the filter module. The draining beds are sealed on alternate sides to the filtrate/unfiltered material chamber, with the known approach any arrangement of filter beds being attainable.

By using beds both for the spacers and also for the filter layers, the known approach makes it possible to stack all beds horizontally without the need for separate support elements for example in the form of support tubes here, as is generally the case for conventional filter elements. Moreover it is possible to stack any filter beds with different filter fineness in any sequence.

But it has been shown in practice that the known filter element can fail especially at high pressures of the fluid which is to be filtered, for example because the deep-bed filter material beds cannot be adequately supported on the spacers in the form of draining beds. The latter can lead to failure of the entire filter element.

EP-B-0 817 668 discloses a filter device which preferably is designed as a bypass flow filter assembly and is used specifically for filtration of hydraulic oil supplies with a motor-driven pump and a permanently mounted filter housing which may be closed with a cover. The filter housing has an interchangeable filter element through which flow can take place from the inside to the outside and which has two cylindrical filter units which are arranged concentrically to its longitudinal axis, which filter units have a radial distance between themselves, and which are held on the end side at least by different cover parts. The unfiltered material which is introduced between the radial spacing of the two filter units is routed in both directions through the respectively assigned filter unit and is filtered in such a manner. Accordingly the filter units, with the formation of the generic prior art, are enclosed to the inside and to the outside by a support element in the form of a support tube which is facing the respective clean side of the known filter element. If the filter element is removed from the filter housing over the cover part of the known design, the filter housing forms a holding vessel for the dirty oil when the filter element is changed and no fouled fluid remains within the filter device; this would lead to dirt in the hydraulic circuit when the filter device is restarted. Although with respect to the inserted support elements in the form of support tubes adequate and secure support of the actual filter units and of

the filter material takes place and hence failure of the filter element is precluded, the cylindrical support tubes on the inner and outer peripheral side have only smooth guide surfaces between which passage points for the fluid are formed. Consequently flow through the known support tubes takes place essentially transversely to their longitudinal alignment so that in the process fluid guidance is restricted, and the known approach cannot be used for special filtration tasks, for example if the intention is to eliminate fluid from the filter units with the filter material by drainage.

DE-A-44 30 341 discloses a generic filter element for filtration of fluid, with a hollow-cylindrical support element for a cup-shaped fluid filter which is closed with a removable cover, especially for oil or fuel, with a filter housing into which an interchangeable filter unit is inserted which consists of a length of filter material which is folded in a star-shape with end disks which are mounted on its two end sides to form a seal, the end disk which is cover-shaped in the installation state of the filter unit forming a fluid opening. The pertinent support element prevents collapse of the filter unit as the fluid stream which is to be filtered flows through it in one direction, and with the known approach it is possible to leave the support element in the filter housing each time the filter unit is changed, so that it is not necessary to dispose of the support element which is not subject to wear together with the filter unit.

In order to achieve improved fluid guidance between the support element and the filter unit which encloses it, in one especially preferred embodiment provision is made such that the support projections be routed around the tubular support element in the manner of a 4-lead spiral along the outside periphery in order to repeatedly deflect the fluid stream around the longitudinal axis of the filter element by 360°. In this case it is characteristic for the known embodiment of the support element that the support projections have sections with different pitches. In this way, a parallel arrangement of a total of four intermediate spaces with the shape of helical lines may be formed between the indicated support projections. These intermediate spaces are available for

directed fluid flow around the outside periphery of the central part as far as the fluid overflow openings which are provided in its upper part. Because the support projections which form the channels run in a helical path, continuous fluid guidance along the tubular support element is prevented and as a result of the aforementioned repeated deflection of the fluid flow, an unfavorable fluid flow characteristic occurs between the support element and the filter unit which encloses it and which is supported on it.

A comparable arrangement is disclosed according to one embodiment as shown in FIG. 3 in WO 01/91881, in this known approach only a helical channel guide which encompasses the support element being used for fluid transport and for supporting the filter unit within the filter housing. Here repeated deflection of the fluid flow around the longitudinal axis of the filter element is unfavorable in terms of energy expenditure and the support projections of the support element which form the helical channel form only a small support surface for the filter unit which is to be supported, so that in this respect reliable support, especially for larger fluid difference pressures, does not take place.

Furthermore, JP-20011293312 A discloses a filter device with a filter unit which is located in a filter housing and in which the support element is provided with a plurality of flow channels which are located on the outer peripheral side, which run in a straight line and which are used for fluid transport within the filter device when oriented to the longitudinal axis of the filter element. In spite of the good support for the filter unit which can be achieved hereby, filtration performance is adversely affected as a result of the known linear fluid guidance.

On the basis of this prior art, the object of the invention is to devise a filter element for filtration of fluid, which permits reliable operation without failure and with which high filtration performance can be achieved in a manner which is favorable in terms of energy expenditure. This object is attained by a filter element with the features specified in claim 1 in its entirety.

In that, as specified in the characterizing part of claim 1, the channels extend continuously without repeated deflections of the fluid stream along the respective support element and in that the channels only partially encompass the respective support element with the formation of a twisting guide, the support element with its longitudinal ribs which border the spiral channels allows reliable support of the filter unit with the assigned filter material during operation of the filter element, and at the same time as a result of the plurality of fluid channels which accordingly are possible large amounts of the fluid which is to be filtered can flow through the filter unit in the direction of the support element.

Since the channels with their longitudinal ribs which border them are guided in spiral tracks in a twisting guide without repeated deflection along the support tube, it has been shown that such a spiral twisting guide accordingly leads to low friction losses in fluid guidance; this in turn has a beneficial effect on the behavior of flow thorough the filter element as claimed in the invention in terms of energy expenditure. The pertinent twisting guide is made in the manner of the helical rifling of low incline, as is made in the barrel of a firearm, by which the round is brought into stabilizing rotary motion. The indicated twisting guide therefore allows channel guidance which extends free of repeated deflections along the respective support element in a tilted alignment to its longitudinal axis. With the filter element design as claimed in the invention moreover different filter tasks can also be carried out, for example when a copious amount of fluid must be quickly removed from the filter unit of the element by draining to improve the filtration performance.

Preferably the respective support element is formed from a support tube and the respective channels are bordered by the longitudinal ribs of the support tube which project laterally; this benefits linear fluid guidance and the cavity and flow losses can be kept low in such a way that the filter element in terms of flow behavior can be described as favorable in terms of energy expenditure.

If in one preferred embodiment of the filter element as claimed in the invention, the channels are located both on the inner and also outer peripheral side on the support tube, the fluid transport performance can be further improved and in this way a support possibility can be found in the two directions for the bordering filter material.

In another preferred embodiment of the filter element as claimed in the invention, the longitudinal ribs may be seated on the support tube in the manner of crosspieces or the longitudinal ribs which are located directly adjacent are connected in pairs to one another and on the outer peripheral side form a support surface and on the inner peripheral side form the base of the groove of the individual channels. Compared to the crosspiece-like arrangement of the longitudinal ribs, the outer peripheral-side support surface in the same manner as the groove base on the inner peripheral side offers a widened contact surface so that consequently improved support for the filter material of the respective filter unit is achieved.

Other advantageous embodiments of the filter element as claimed in the invention are specified in the other dependent claims.

Reference will now be made to the drawing of the filter element as claimed in the invention and in which in schematic form and not drawn to scale

FIG. 1 is a section of a longitudinal view through the filter element;

FIG. 2 in schematic form is a top view of the filter element as shown in FIG. 1 without the cover parts and without the filter units, and

FIG. 3 in schematic form is a view of a modified embodiment of one support element in the form of a support tube relative to the inserted support elements as shown in FIG. 2.

One embodiment of the filter element as claimed in the invention is shown in FIG. 1 in the manner of a longitudinal section. The filter element is used for filtration of fluids, especially in the form of dirty hydraulic oil or the like. Three filter units 12, 14, 16 are arranged around the longitudinal axis 10 of the filter element concentrically to the latter. For the sake of clarity the filter unit 12 which is located outermost has been shown only with half its axial length. The indicated filter units 12, 14, 16 each have a radial distance between each other and on the inside are held by two cover parts 18, 20 designed as end caps. In particular, the ends of the filter units 12, 14, 16 can be joined to the two cover parts 18, 20 by way of a bed of adhesive or the like.

In the cover parts 18, 20 there is a fluid guide which is designated as a whole as 22. The type of fluid passage and the type of internal fluid guide 22 are shown in FIG. 1 with the corresponding arrows, flow taking place through the filter element in the direction of the arrow. Furthermore, in the respective distance between the filter units 12, 14, 16 a support element 24, 26 is placed as a support and/or drainage tube. Depending on the flow direction of the fluid which is to be filtered (unfiltered material), at least some of the filter units 12 and 14 which border adjacently are thus effectively supported in the flow-through direction by way of the assignable support elements 24, 26 in order thus to prevent bulging of the respective filter unit 12, 14, 16. Furthermore, the support elements 24, 26 are provided with channels 28 as another part of the internal fluid guide 22. The pertinent channels 28 are shown in FIG. 2 for the two support elements 24 and 26 for one embodiment on the support elements 24, 26.

The respective filter unit 12, 14, 16 is formed from a cylindrical filter mat, and the pertinent filter mat may be wound or folded and consists of a filter material which is conventional in this field. As furthermore follows from FIG. 1, the respective filter mat is provided with a uniform linear dimension, like the other inserted cylindrical filter mats, measured in the direction of the longitudinal axis 10 of the filter element. The filter unit 16 which is located innermost viewed in the direction of looking at FIGS. 1 and 2 is supported on the inner peripheral side on a support tube 30 with an interior which is connected to the clean side 32 of the filter element (see FIG. 1). The structure of the pertinent support tube 30 is of conventional design and is known from another connection, said support tube consisting of individual annular segments 34 which are located on top of one another, which border the fluid passages for passage of the filtrate between one another, and the support crosspieces 36 which border over three identical angles between themselves being kept at a distance to one another (see FIG. 2). Thus the inner, conventionally made support tube 30 supports the innermost filter unit 16 when flow-through takes place in the direction from the outside (compare arrow 22) to the inside. In the embodiment as shown in FIG. 2 there are a total of 40 fluid channels 28 both on the inner and also the outer peripheral side on each of the two support elements 24, 26. Preferably in any case always more than 20 fluid channels 28 are used for one of the indicated support elements 24, 26. Thus, in the embodiment as shown in FIG. 3 which will be detailed below, there are 24 channels 28 respectively both on the inner and also the outer peripheral side.

The cover part 18 which is the upper one when viewed in the direction of looking at FIG. 1 consists essentially of two parts 38, 40 which can each be joined integrally to one another. The upper part 38 is provided with a mountable handle 42 designed as a grip in order to remove for example the filter element from the filter housing of the filter device (not shown) when the filter element has been used up and so to replace it with a new filter element. The fouled and unfiltered fluid (unfiltered material) can be supplied to the filter element by way of inlets 44 designed as holes which are arranged diametrically to the longitudinal axis 10, the pertinent inlets 44

extending through the two parts 38 and 40 of the upper cover part 18. The upper cover part 40 is elongated downward in the middle as a shoulder and in the middle encloses a central channel 46 which leads to the clean side 32 within the filter element by way of the support tube 30.

Furthermore, in the upper cover part 18, as part of the internal fluid guide 22 there are flow channels (not shown) which make it possible, as shown in the partial representation in FIG. 1, to accommodate already filtered fluid by way of the filter units 12 and 14 and to transport it in the direction of the central channel 46 to the clean side 32 of the filter element. The cover part 20 which is the lower one when viewed in the direction of looking at FIG. 1 is designed accordingly like the upper cover part 18, and instead of the handle 42 however the lower cover part 20 has the clean side 32 of the filter element which is enclosed by a jacket connection 48.

As shown particularly in FIG. 2 which relates to one embodiment of the filter element, the two support elements 24 and 26 are made cylindrical and along their outer and inner periphery each have longitudinal channels 56, 58, 60, and 62 which can be regarded as part of the internal fluid guide 22. The respective longitudinal channel 56, 58, 60, and 62 of the assignable support element 24 and 26 is equidistant to the next following longitudinal channel on the inside or outside of the pertinent support element, the longitudinal channels 56, 58, 60, and 62 along the longitudinal axis 10 of the filter element having a twist such that a type of twisting guide for the fluid which is to be transported is achieved.

The indicated filter element is used for installation in a conventional filter device which has an inlet point for the filtered fluid [sic] and an outlet point for the filtered fluid (filtrate) (not shown).

In order to detail the operation of the filter element as claimed in the invention, this is shown using the arrows in FIG. 1.

When viewed in the direction of looking at FIG. 1, to the right of the longitudinal axis 10 of the filter element the internal fluid guide 22 is detailed. By way of an inlet point which is not detailed in the filter housing for the filter element shown in FIG. 1, the unfiltered material flows from the outside to the inside through the first filter unit. The contaminants present in the unfiltered material are then retained in the first filter unit 12 and the fluid flow of filtrate is taken up on all sides and on the outer peripheral side by way of the outer longitudinal channels 56 of the first support element 24 and is discharged in equal parts up and down into the upper cover part 18 and into the lower cover part 20. The filtrate is then taken up into the respective bottom part by way of the internal fluid guide 22 in the cover parts and transported in the direction of the central channel 46, from where discharge takes place by way of the middle of the support tube 30 between the support crosspieces 36 in the direction of the clean side 32. At the same time, in the direction of the arrows 66 additional unfiltered material is introduced into the filter element by way of the filter housing which is not detailed, specifically by way of the inlets 44 which are separated fluid-tight from the other internal fluid guides within the cover parts 18, 20.

The unfiltered material which is supplied by way of the inlets 44 travels by way of the upper cover part 18 and the lower cover part 20 into the longitudinal channels 60 and 62 of the second support element 26 and the pertinent unfiltered material is then sent uniformly in both directions once through the inner third filter unit 16 and once through the middle filter unit 14. The latter stream of filtrate is then transported in turn by way of the inner guide channels 58 of the first support element 24 into the cover parts 18, 20 and in turn travels by way of the internal cover fluid guide to the clean side 32 of the filter element, as described. The other branched filtrate flow then travels by way of the third filter unit 16 into the interior of the support tube 30 and from there likewise to the clean side 32 of the filter element. The pertinent internal fluid guide 22 is shown by way of example for one flow path, this taking place, as described, radially

on the outer peripheral side along the individual filter units 12, 14, 16 and the support elements 24, 26.

By the concentric arrangement of several filter mats around the aforementioned support tube 30, one drainage tube in the form of support elements 24, 26 each being located between two filter mats, the available installation space in the filter housing of a filter device (not shown) is more effectively used, whereby an increase of the dirt-holding capacity can be achieved and the flow resistance of the filter element is accordingly reduced by the enlargement of the filter area so that the entire filter element can be characterized as favorable in terms of energy expenditure for the throughflow process. As shown, some of the drainage tubes are designed to supply the filtered fluid in the two end caps in the form of cover parts 18, 20, whereas another part is designed to supply the unfiltered fluid (unfiltered material) from the two end caps to the filter mats. The indicated drainage tubes as support elements 24, 26 which in the same way as the support tube 30 form a support function for the assignable filter units 12, 14, 16, can be made as shown in FIG. 3 also in the manner of a corrugated tube or also as rings which are stacked on top of one another with holes (not shown). Due to the indicated arrangement as shown in FIG. 1, it applies to each drainage tube that the pressure on its inside corresponds to the pressure on its outside so that for the filter element overall a pressure-compensated arrangement is achieved; this has a beneficial effect on the service life of the filter element.

In a different embodiment of a support element 24, 26 as shown in FIG. 3, the longitudinal ribs 50, which are arranged directly adjacent, are connected to one another in pairs and on the outer peripheral side form a support surface 68 and on the inner peripheral side a groove base 70 of the individual channels 28. Opposite the crosspiece ends of the longitudinal ribs 50 according to the first embodiment as shown in FIG. 2, the supporting contact surfaces for the assignable filter units 12, 14, 16 are consequently elevated by way of the support surfaces 68 and the groove base 70; this suggests that the embodiment as shown in Figure 3 is especially

well suited if the pertinent filter units and filter materials are exposed to high compressive stresses and compressive stress cycles as the fluid flows through.

The embodiment as shown in FIG. 3 can be combined with the embodiment as shown in FIG. 2 for a filter element, for example by the embodiment as shown in FIG. 3 forming the innermost support element 26 and the arrangement with the raised longitudinal ribs 50 forming the outermost support element 24. But two or more support elements according to the embodiment as shown in FIG. 3 arranged concentrically to one another can also form a drainage tube system for a filter element. If depending on the filtration task this should be necessary, the respective support element 24, 26 can also be provided with perforations which are not detailed, in order to achieve fluid passage transversely to the longitudinal axis 10 of the filter element in this way. The pertinent perforations (not shown) may penetrate the channels 28, but also in the embodiment as shown in FIG. 3 the support surface 68 along with the groove base 70. The support element 24, 26 which is designed as a corrugated tube as shown in FIG. 3 can also be easily obtained as an extrusion part from plastic material.